HYDROLOGY

Precipitation

The North Fork Watershed is situated in one of the wetter parts of the state. Data available from the National Climatic Data Center (NCDC 1999) for 10 National Weather Service and cooperative stations located in and near the watershed, indicate an average annual precipitation of 43.26 inches for the period of 1946 to1995(Figures Hy01 and Hy02). This time period has been chosen for analysis of certain hydrological characteristics of the watershed in order to make use of the most complete and long-term precipitation and discharge data available. The maximum recorded annual precipitation amount at an individual station during this period is 65.37 inches, while the minimum recorded annual precipitation during this period is 20.31 inches.

Average annual precipitation in the watershed has increased over time. A comparison of average annual precipitation for two time periods, 1946 to1970 and 1971 to1995, indicates an increase of 2.55 inches within the watershed. Figure Hy02 shows annual precipitation amounts as well as average annual amounts for the previously discussed time periods. Average monthly precipitation data for the period 1946-1995 indicates that the combined months of April, May, and June receive the most precipitation at 13.42 inches. The combined months of December, January, February receive the least amount of precipitation at 8.45 inches. Average monthly precipitation data also indicates that May receives the most precipitation while January receives the least (Figure Hy03). Distribution of monthly precipitation amounts has shifted over time. Average monthly precipitation comparisons between the periods 1946 to 1970 and 1971-1995 indicate an increase in precipitation in 8 of the months, while the other 4 months have experienced a decrease in precipitation. The most notable change has been an increase in the amount of average monthly precipitation occurring in the months of September, October, November, and December (Figure Hy04).

United States Geological Survey Gauging Stations

The United States Geological Survey (USGS) currently (1999) has two active stream discharge gaging stations within the North Fork River Watershed. Station #07057500 is located on the North Fork River, 3.5 miles northeast of Tecumseh upstream from Dawt Mill (USGS 1999a). The datum of the gage is 584.67 ft above sea level. Station #07057500 has been recording water stage data from October 1944 to the present. Station #07058000 is located on Bryant Creek 0.8 miles downstream from Caney Creek near Tecumseh (USGS 1997). The datum of the gage is 573.15ft above sea level (USGS 1997) (Figure Hy01). Historical records from station #070578000 exist from 1944-1985 1994-1996, and 1997-1998. Historical water stage and discharge records exist from eleven other sites positioned throughout the watershed (Table Hy01 and Figure Hy01)(MDNR 1994, USGS 1998, and USGS 1999b).

Average Daily Discharge

Long-term discharge data exists for the two operational gage stations, one on the North Fork River near Tecumseh (07057500) and the other on Bryant Creek near Tecumseh (07058000). The average daily discharge at gage station 07057500 for the last 54 years is 756 cubic feet per second (cfs) with the number of observations (n) equaling 19,723 (USGS 1999c). The average daily discharge at gage station 07058000 for the 43 years of record is 534 cfs (n=16,121) (USGS 1999d). Average daily discharge at both stations was lowest during the months of August, September, and October and highest during

March, April and May (Figures Hy05 and Hy06). Comparison of two time periods, 1946 to 1970 and 1971 to 1995 indicates a substantial increase in average daily discharge at both stations 07057500 and 07058000 during the latter time period. Station 07057500 has experienced an increase of 134 cfs while Station 07058000 has experienced an increase of 85 cfs. Analysis of percent change in average daily discharge by month between two time periods indicates a substantial increase in the months of March, April, September, November, and December coupled with a notable decrease in July (Figure Hy04).

Months with the lowest amount of precipitation do not necessarily exhibit the lowest flows within the watershed. As indicated previously, the combined winter months of December, January, February receive the least amount of precipitation. However the lowest daily flows occur during the late summer/early fall months of August, September, and October. Increased evaporation and transpiration rates during this period may explain this.

Flow Duration

Flow duration curves are useful for inter/intra watershed comparisons of discharges. Daily flow duration data available from the United States Geological Survey (USGS) Daily Values Statistical Program (DVSTAT) (1999e) was compared to determine if the North Fork River and Bryant Creek had become more or less susceptible to flooding or drying in recent years. Figure Hy07 indicates the duration of flows from 1946 through 1970 and 1971 through 1995 on the North Fork River near Tecumseh. Figure Hy08 indicates the duration of flows from 1946 to 1970 and 1971 through 1985 plus data from 1994 and 1995 on Bryant Creek near Tecumseh.

The flow duration curves from the latter time period have made an upward shift indicating higher discharges at both stations. The upward shift of the flow duration curve reflects, in part, an overall increase in discharge in the latter time period. The changes in the flow duration curve and discharge rates are an indication of possible changes in precipitation, land use, and/or spring output. Changes in the amount, intensity, seasonal timing, and/or duration of precipitation could impact discharge. As stated previously, the area of the watershed has experienced an overall increase in average annual precipitation during the last 25 years. In addition seasonal timing of this rainfall has changed over the past 25 years (Figure Hy04). Data on intensity and duration of precipitation is unavailable. Land use practices can significantly alter flow duration and discharge. A change in land use from pasture or clear-cut to timber can slow the rate of surface runoff, alter the ratio of surface to subsurface flow, and reduce over-bank flow velocities. The variability of land use data collection methodology and analysis makes it difficult to reliably determine actual land use/land cover changes which have occurred within the watershed for the previously discussed time periods. If significant changes have occurred, it would seem that changes in the slopes of the flow duration curves would be apparent. However, while the curves have shifted upward for both stations (probably due to increased precipitation), neither has experienced a significant change in slope. Thus flow duration does not appear to have been significantly altered by any change in land use in the watershed.

A comparison of flow duration curves for the time period 1946-1995 for both the North Fork River and Bryant Creek stations indicate a slightly steeper curve for Bryant Creek (Figure Hy09). This is perhaps due to the fact that a large amount of water within the upper portion of Bryant Creek is thought to be lost to the ground water system to reemerge in the North Fork thus sustaining the latter for extended periods of time. Another explanation is that perhaps the slightly lower percentage of forest/woodland cover within the Bryant Creek Subwatershed promotes an increased rate of runoff which decreases the

sustainability of discharges over time. However the percentage difference is so negligible (<5%), that it is difficult to determine, with certainty, if this is one of the primary causes. In addition, average gradients for fourth order and larger streams within the Bryant Creek Subwatershed are slightly higher than those of streams in the North Fork Drainage above Bryant Creek. This would lead to a higher rate of runoff and thus a steeper flow duration curve.

10:90 Ratio

The ratio of the flow rate which is equaled or exceeded 10% of the time to the flow rate which is equaled or exceeded 90% of the time is called the 10:90 ratio. The 10:90 ratio for the North Fork River near Tecumseh is 5:1. The 10:90 ratio for Bryant Creek near Tecumseh is 8:1. The 10:90 ratios at both of these sites are considered low. Low 10:90 ratios are indicative of low overall flow variability. In the North Fork Watershed, ground water contributes significantly to the overall water supply to the North Fork and Bryant Creek. Therefore, flow in these streams would be less affected by fluctuations in precipitation amounts over relatively short periods of time than streams with higher ratios.

Instantaneous Discharge

Table Hy02, lists the highest and lowest instantaneous discharge rates that have occurred at each of the above sites during the period of record.

7-day Q2, Q10, Q20 Low Flow and Slope Index

Seven day low flow statistics were computed for the two currently operating gage stations within the North Fork Watershed. The North Fork River near Tecumseh has seven day Q2 and Q20 low flow values of 295 and 195 cfs, respectively. Bryant Creek near Tecumseh has seven day Q2 and Q20 low flow values of 150 and 100 cfs, respectively.

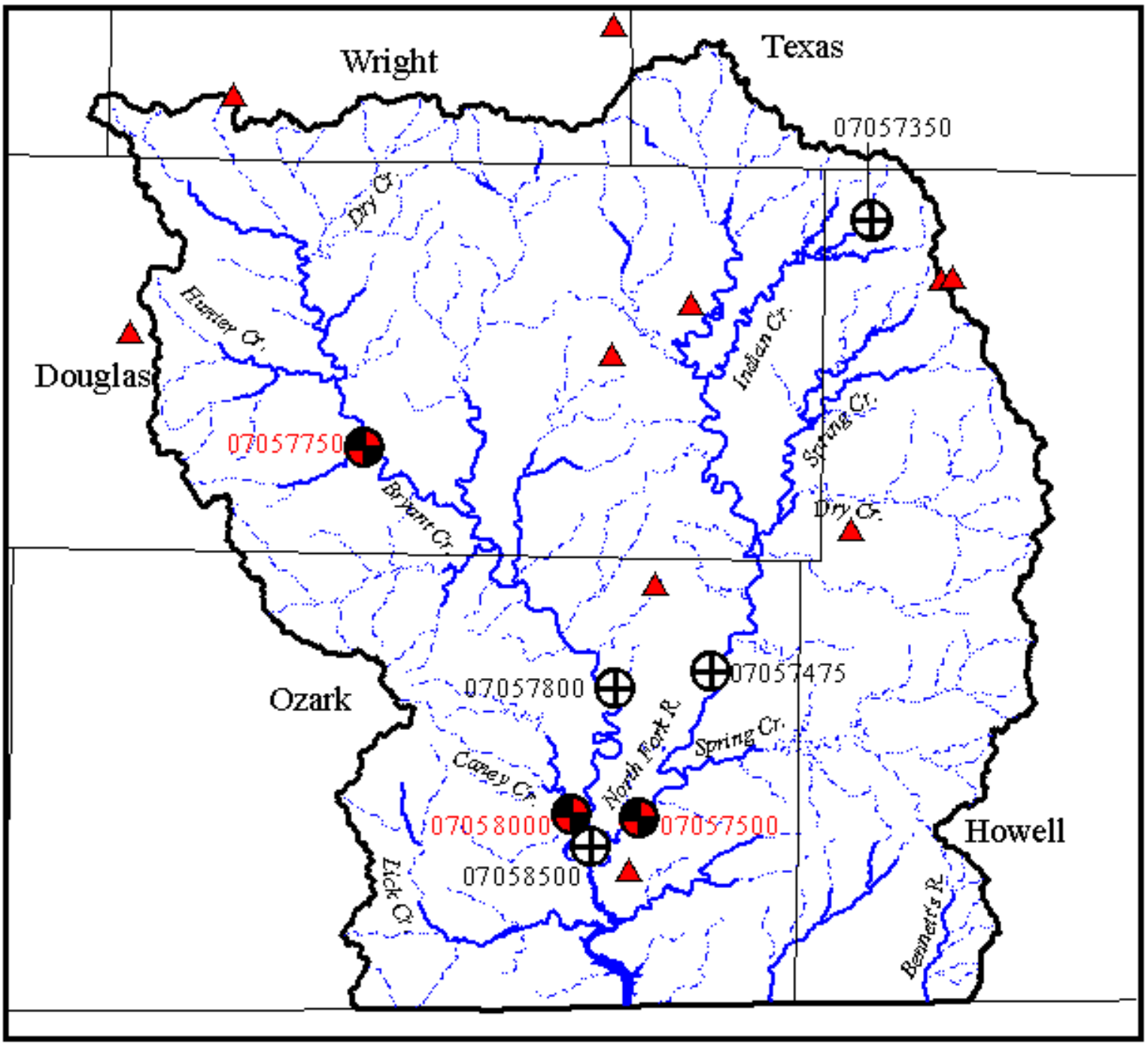
Slope indices (SI, ratio of the seven day Q2 to Q20) were calculated for the North Fork River near Tecumseh and Bryant Creek near Tecumseh. The SI were 1.5 for both sites. These are extremely low slope indices, an indication of low variability in annual low flows.

Flood Frequency

Table Hy03 indicates the frequency and magnitude of flooding on the North Fork River and Bryant Creek near Tecumseh. The watershed areas above the gage stations on the North Fork River and Bryant Creek are 561 and 570 square miles, respectively (USGS 1997 and USGS 1999a). As the similarities in the size of the watersheds would suggest, the flood frequency and magnitudes on the North Fork River and Bryant Creek are very similar to each other. The frequency and magnitude of the floods on the North Fork River and Bryant Creek are comparable to streams of similar size within the Ozark Region.

Figure Hy01.

North Fork Watershed
Hydrologic Stations



5 0 5 Miles

Legend

Watershed Boundary

N

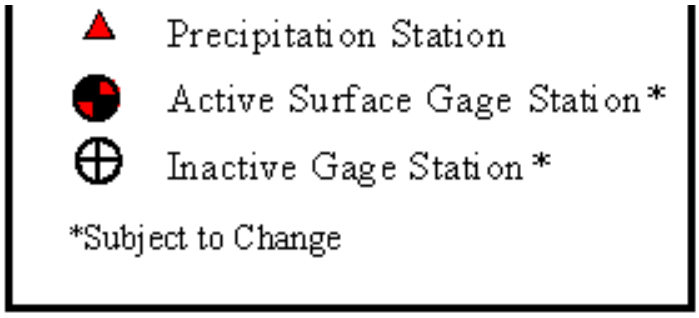

Precipitation Station
Active Surface Gage Station*
Inactive Gage Station*
*Subject to Change

Figure Hy02. Mean annual precipitation amounts from National Weather Service and cooperative stations in and near the North Fork Watershed for years 1946-1995 (NCDC 1999). n=number of annual measurments available for period of record.

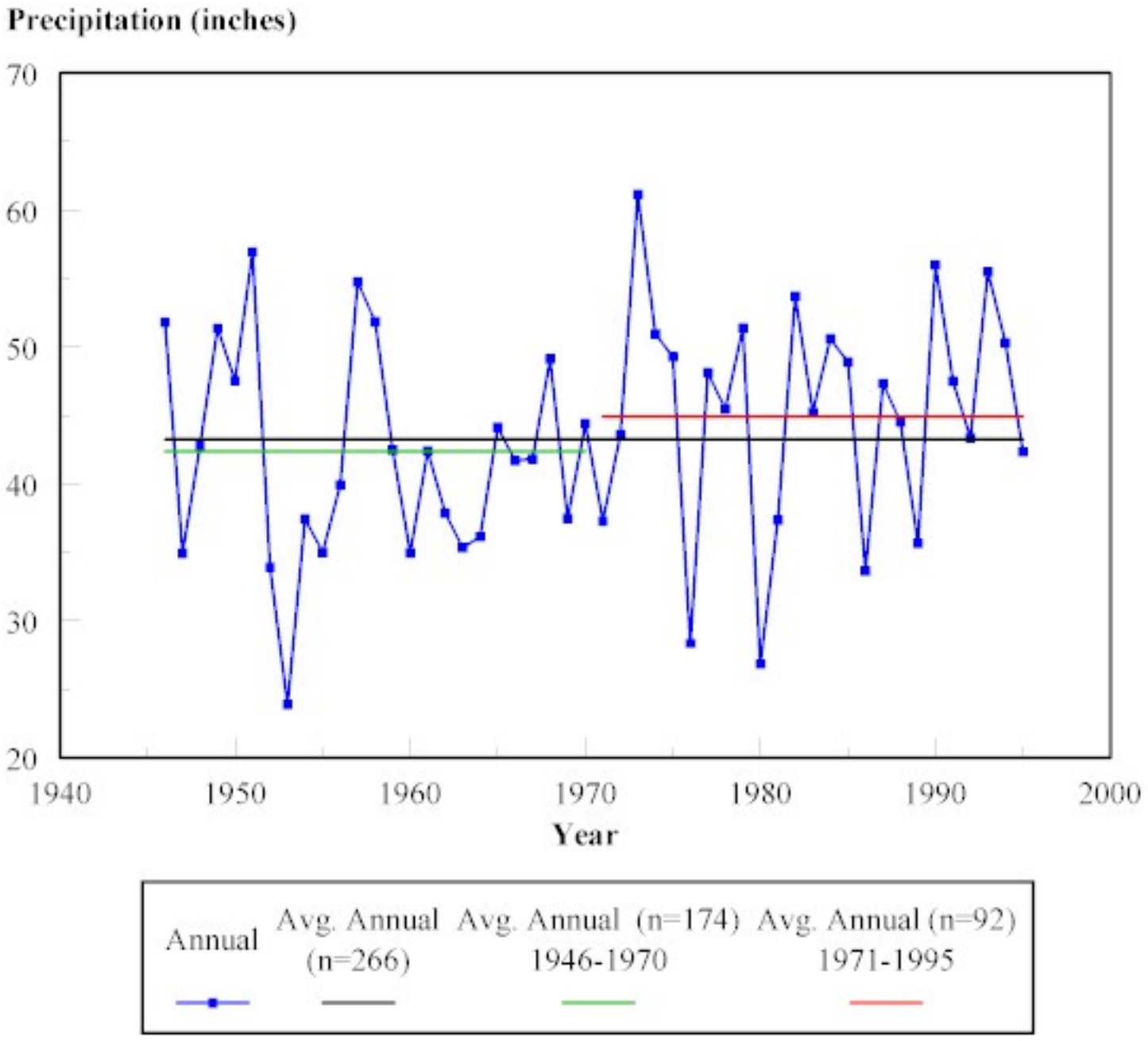


Figure Hy03. Average monthly precipitation amounts from National Weather Service and cooperative stations in and near the North Fork Watershed. (NCDC 1999).

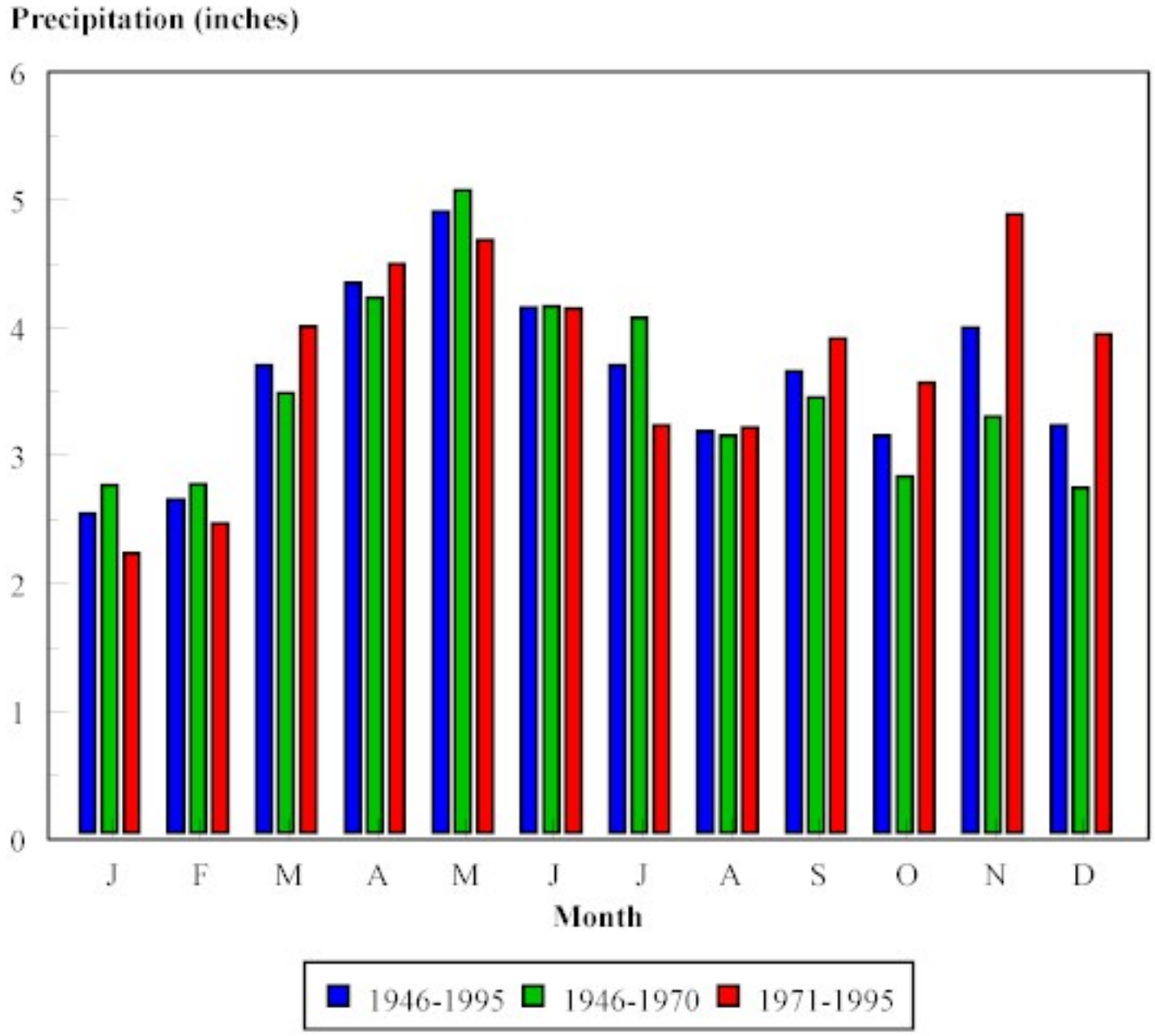


Figure Hy04. Change in mean daily flow as well as precipitation by month between two time periods (1945-1970 and 1971-1995).

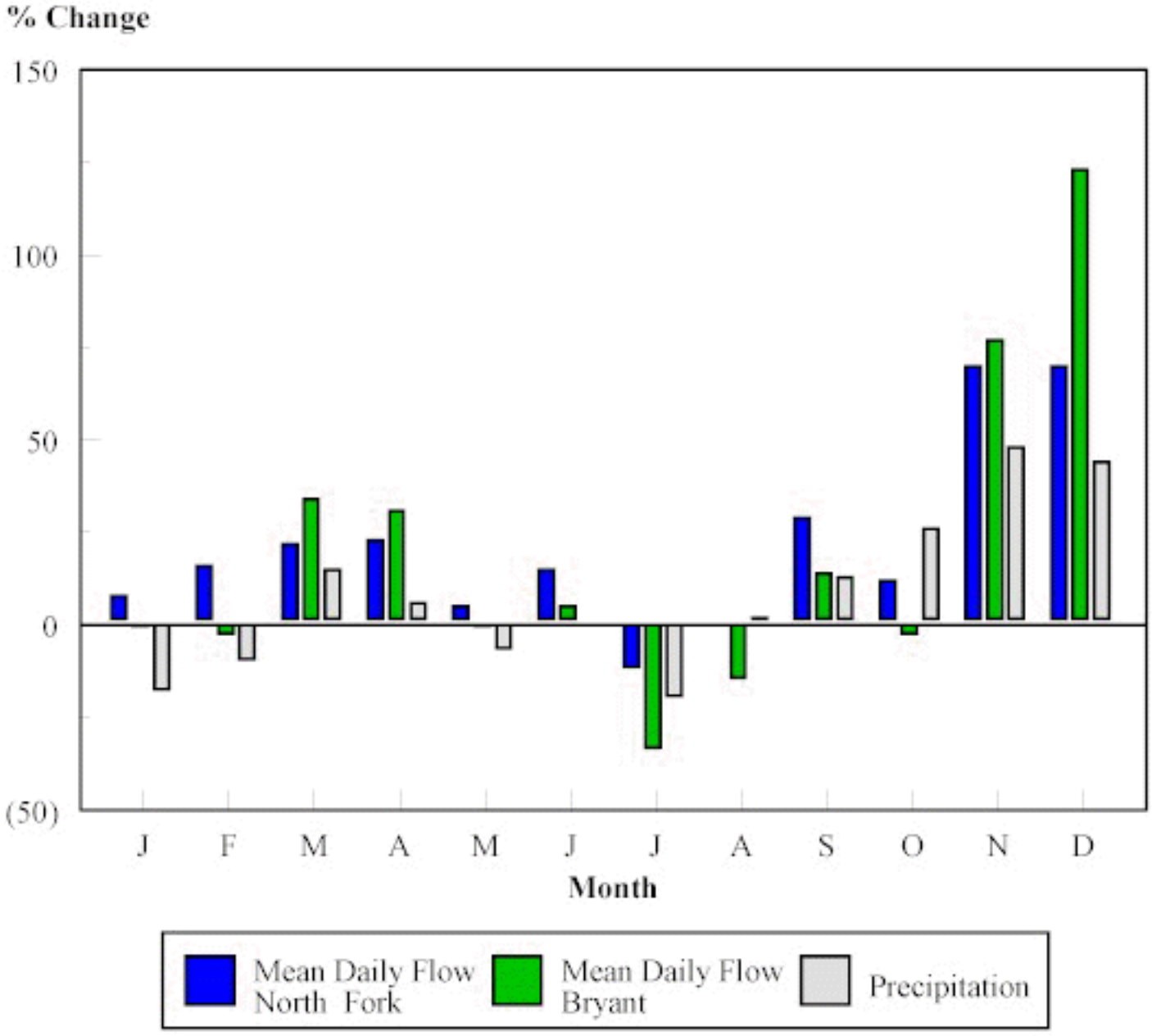


Figure Hy05. Average daily flow by month at USGS Gage Station 07057500 (North Fork River near Tecumseh, Missouri)

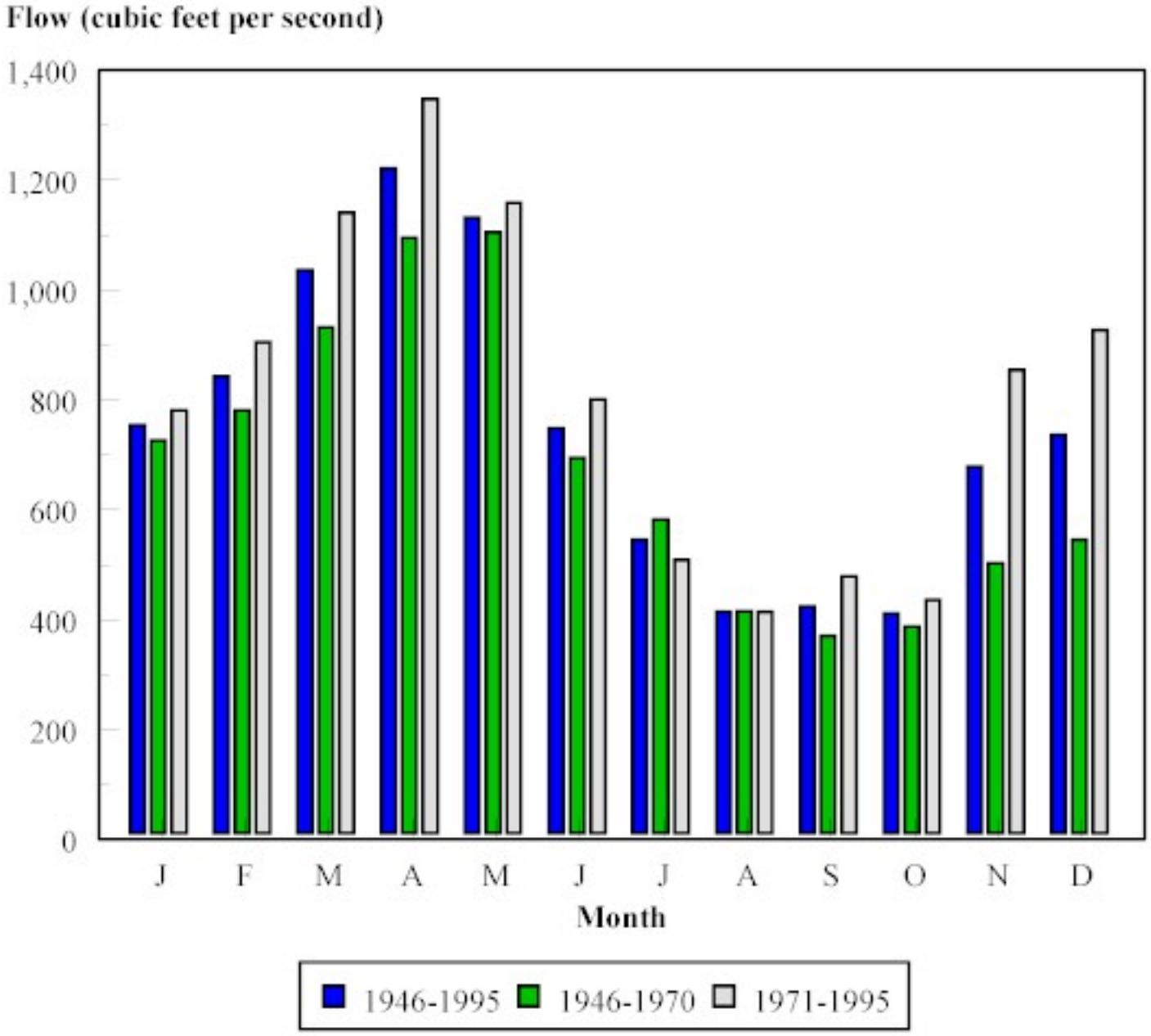


Figure Hy06. Average daily flow by month at USGS Gage Station 07058000 (Bryant Creek near Tecumseh, Missouri)

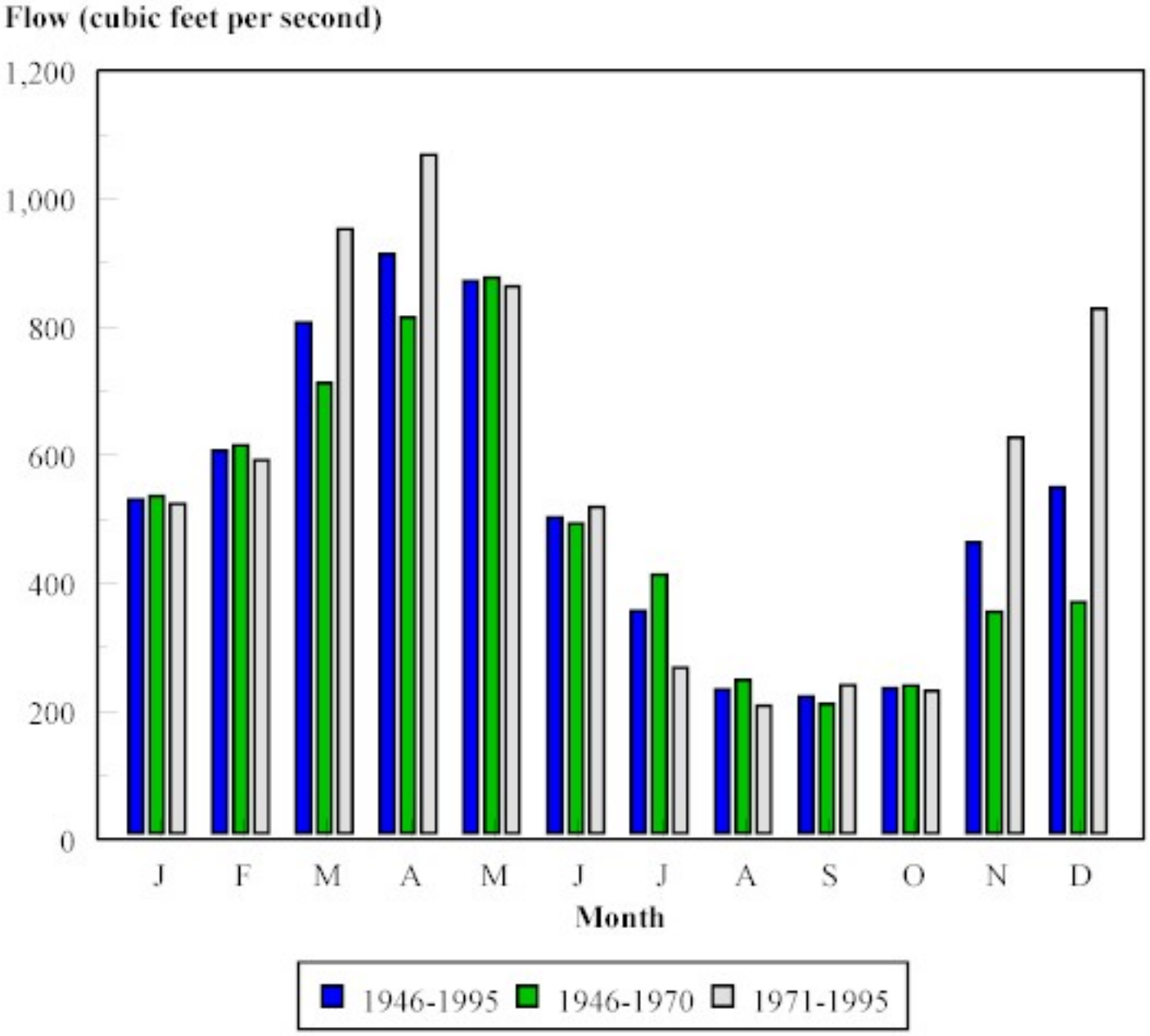


Figure Hy07. Flow duration changes between two time periods for Station 07057500 (North Fork near Tecumseh) (USGS 1999e).

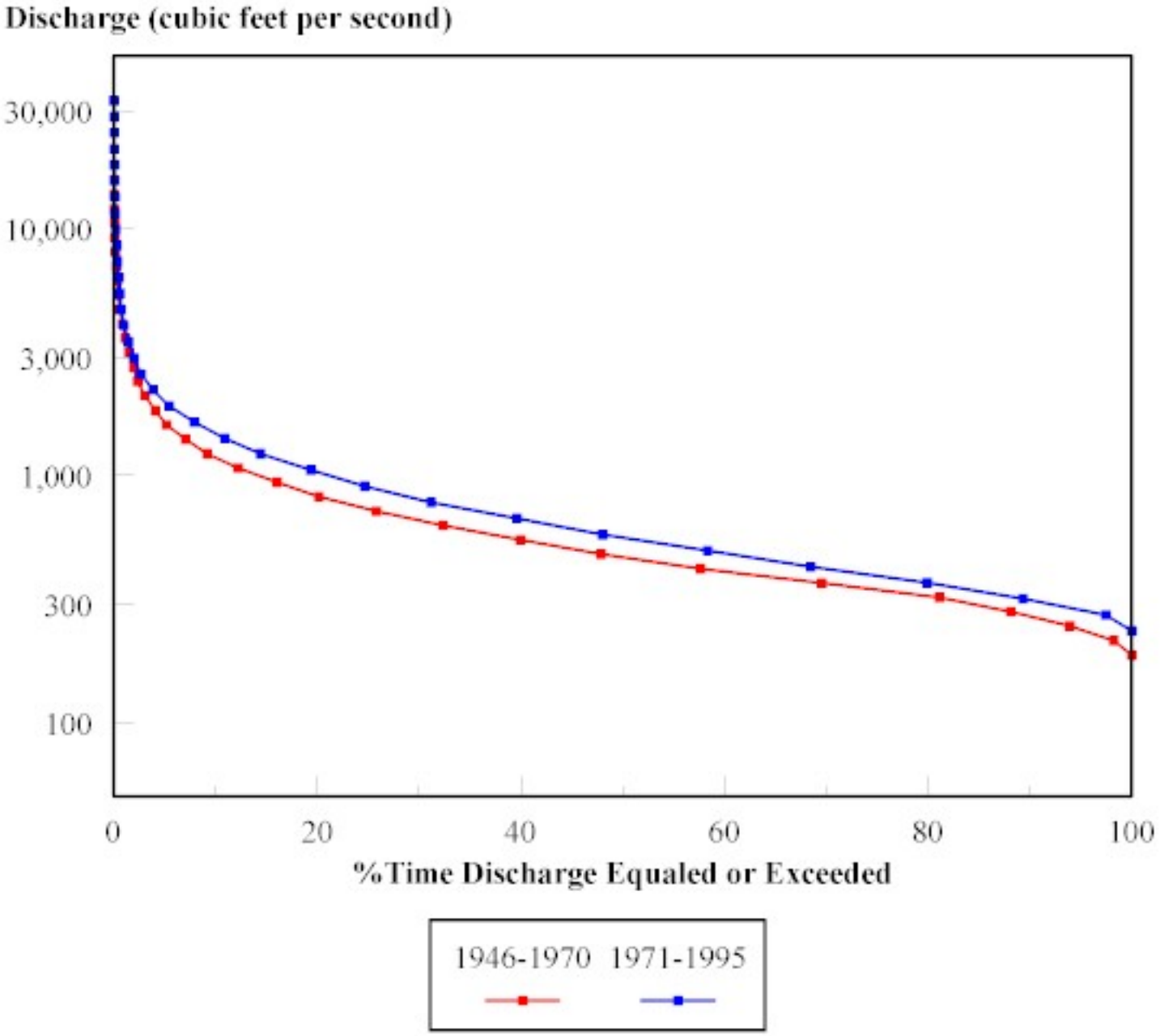


Figure Hy08. Flow duration changes between two time periods for Station 07058000 (Bryant Creek near Tecumseh) (USGS 1999e).

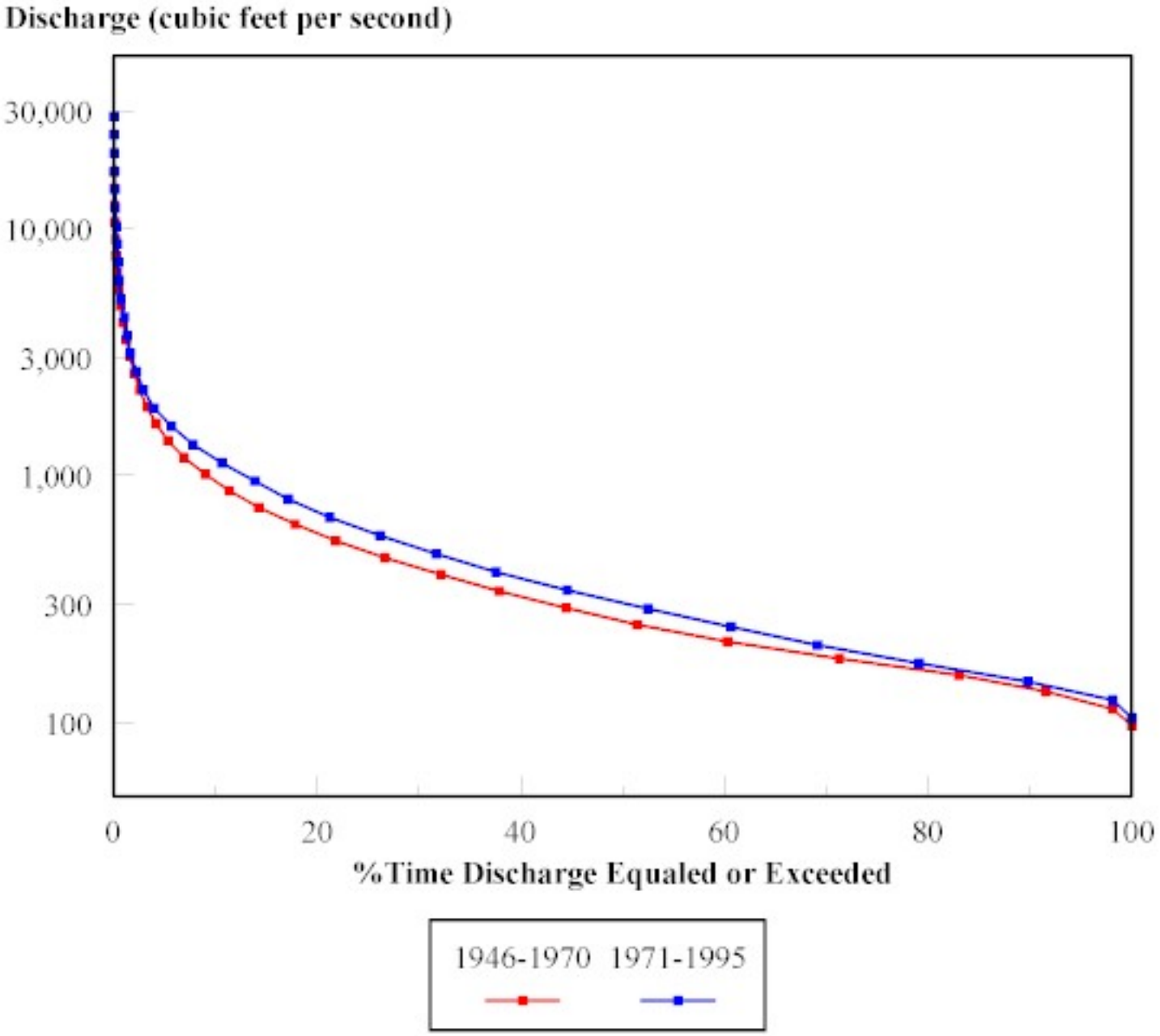


Figure Hy09. Comparison of flow duration for Station 07057500 (North Fork River near Tecumseh) and Station 07058000 (Bryant Creek near Tecumseh) (USGS1999e).

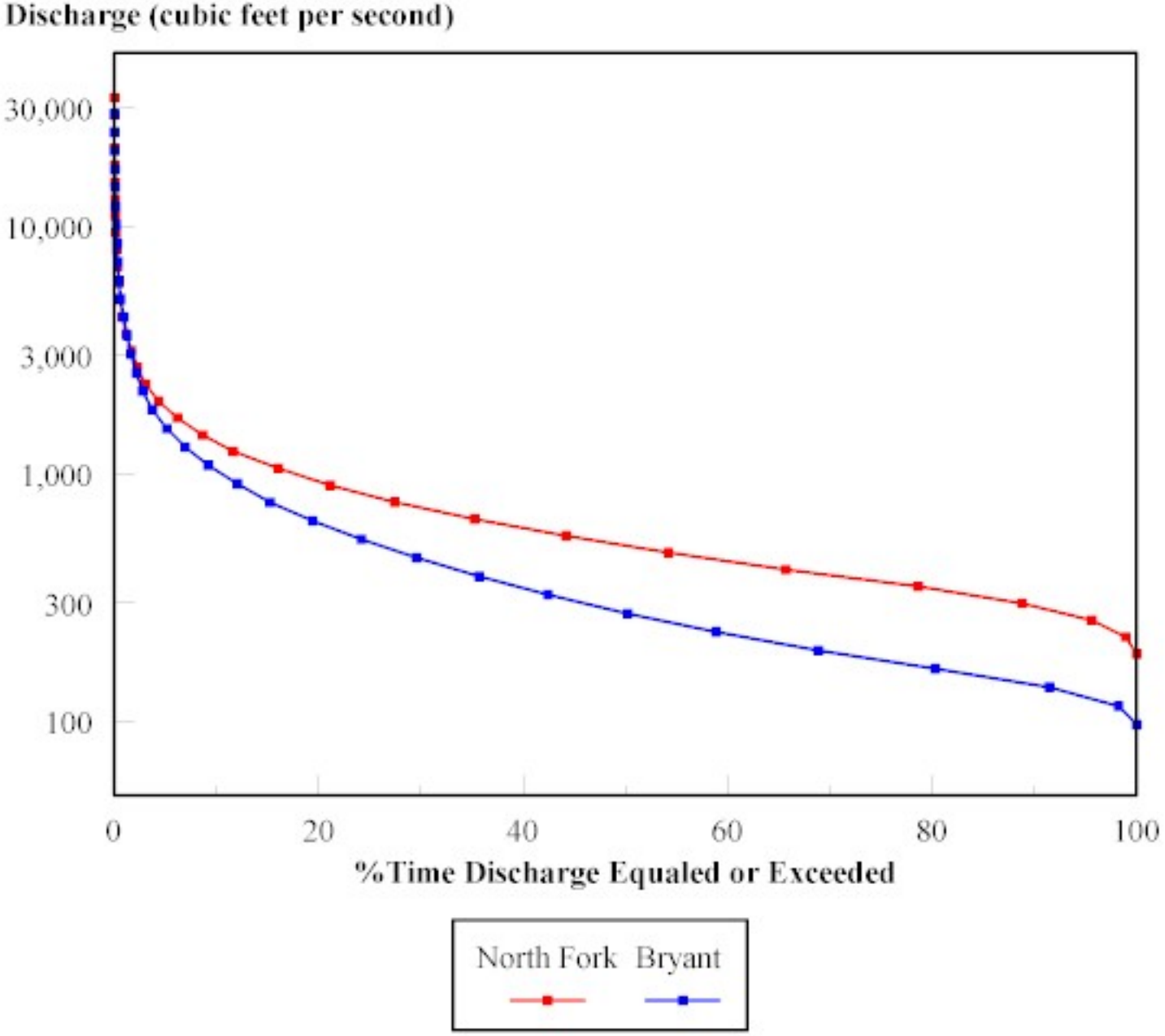


Table Hy01. Stations and other sites with significant flow and/or water quality data within the North Fork Watershed (MDNR 1994, USGS 1998a, and USGS 1999b).

Station Number	Station Name	County	Period of Record
07057350	Tributary to Middle Indian Cr. near Cabool, MO.	Howell	1985-1987
07057360	Middle Indian Cr. near Cabool, MO.	Howell	1985-1987
07057500	North Fork River near Tecumseh, MO.	Ozark	1944-1996
07057800	Hodgson Mill Spring at Sycamore, MO.	Ozark	1926, 1932, 1934, 1936, 1964-1972
07058000	Bryant Creek near Tecumseh, MO.	Ozark	1944-1985, 1994-1996
07058500	North Fork River at Tecumseh, MO.	Ozark	1921-1932, 1932-1944
07057475	Double (Rainbow) Spring near Dora	Ozark	1919, 1924-1925, 1934, 1936, 1942, 1964-1972
N/A	North Fork River at Twin Bridges	Ozark	1962-67

N/A	Crystal Spring near Ava	Douglas	1925, 1934, 1936, 1954, 1964, 1967-1968
N/A	Blue Spring near Dora	Ozark	1926, 1932, 1934, 1936, 1964, 1967-1968
N/A	Bryant Creek near Evans	Douglas	1964-1967, 1969, 1971
N/A	Spring Creek at Twin Bridges	Ozark	1962-1967

Table Hy01. Stations and other sites with significant flow and/or water quality data within the (continued) North Fork Watershed (MDNR 1994, USGS 1998a, and USGS 1999b).

Station Number	Station Name	County	Period of Record
N/A	Wilder Spring near Elijah	Ozark	1924-1925 1932,1936 1966-1967
N/A	North Fork Spring near Dora	Ozark	1964, 1966-1971

N/A	Althea Spring near Tecumseh	Ozark	1926, 1932, 1934, 1936, 1943, 1959, 1964, 1967-1968, 1971

Table Hy02. Highest and lowest instantaneous discharges and date of occurrence at the two operational gage stations within the North Fork River Watershed (USGS 1997 and 1999a).

Station Number	Station Name	Period of Record	Instantaneous Peak Flow & Date	Instantaneous Low Flow & Date
07057500	North Fork R. near Tecumseh	1944-1998	133,000 cfs 11/1985	187 cfs 9/1954
07058000	BryantCreek near Tecumseh	1944-1985, 1994-1996	71,100 cfs 12/1982	96 cfs 9/1954

cfs=cubic feet per second.

Table Hy03. Magnitude of flood events (cubic feet per second) for selected recurrence intervals (years) at two sites in the North Fork Watershed (Alexander and Wilson 1995).

	Recurrence Interval						
Site	**2**	**5**	**10**	**25**	**50**	**100**	**500**
North Fork R. at Tecumseh	11,700	23,300	33,400	50,800	67,300	87,200	150,000
Bryant Cr. at Tecumseh	11,600	21,100	28,400	38,400	46,400	54,700	75,200